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Seasonal aerosol acidity and liquid water content: impact on aerosol concentration and nitrogen deposition fluxes in a urban Canadian environment.

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Aerosol acidity and liquid water content (LWC) affect aerosol concentration and composition as well as the fate of the precursor compounds ammonia (NH_3) and nitric acid (HNO_3) [1,2]. Together with temperature, aerosol acidity and LWC determine the gas-particle partitioning of such precursors. In warm seasons, high aerosol acidity and low LWC promote the partitioning of NH_3 to particulate phase as ammonium, while at the same time drive aerosol nitrate to the gas phase as HNO_3. In cold seasons, the opposite effect can be observed. Given that the dry deposition rate of gaseous NH_3 and HNO_3 is up to 10 times faster than the particle phase, the conditions that favour the partitioning of these species to the gas phase also determine the dry deposition rates of reduced and oxidized nitrogen. This process has consequences for the accumulation of aerosols in the boundary layer, as well as the transport and deposition flux of nitrogen species[2].

In the present work, we explore the seasonal variation of aerosol acidity and liquid water content and their estimated effect on nitrogen dry deposition velocity using data collected over three years in Toronto, Canada, from January 2016 to December 2018. Aerosol acidity, in terms of H^+ concentration, has large inter- and intra-seasonal variability, ranging between 5 and almost 3 orders of magnitude, respectively. By applying the framework developed in Nenes et al. 2020 [1], aerosol formation during winter is sensitive to HNO_3 levels (pH range

~3 and ~6, LWC range ~0.4 and ~ 35.0 μg m^{-3}), whereas in summer it tends to be insensitive to both NH_3 and HNO_3 (pH range ~1.4 and ~ 4, LWC range ~0.04 and ~10.0 μg m^{-3}) This insensitive regime indicates that emissions of other precursors such as SO_x and organic aerosol are major sources of aerosol variability in summer. In terms of nitrogen dry deposition, the seasonal variation experiences two regimes: in winter, the deposition is fast for NH_3 and slow for HNO_3, whereas in summer, both deposition of NH_3 and HNO_3 are fast.

In conclusion, the analysis of ambient aerosol data using aerosol pH and liquid water content suggest that in Toronto, emission controls of NO_x in winter and of SO_x in summer would be most beneficial for air quality.

[1] Nenes A., Pandis S., Weber R.J., Russell A., ACP, 20, 3249–3258, 2020

[2] Nenes A., Pandis S., Kanakidou M., Russell A., Song S., Vasilakos P., Weber R.J., ACPD, 20, 266, 2020